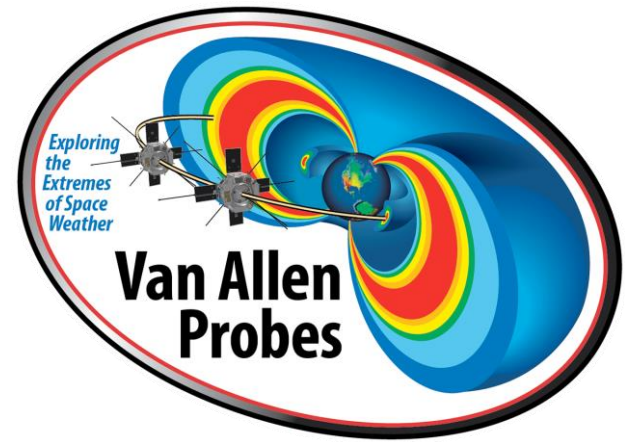


# Space Weather with NASA's Van Allen Probes

Mona Kessel, NASA HQ



See also *The Radiation Belt Storm Probes and Space Weather*  
by Kessel et al., Space Sci Rev DOI 10.1007/s11214-012-9953-6

# Van Allen Space Weather Data

Space weather data is being generated and broadcast from the spacecraft 24/7 when not sending science data. The mission targets one part of the space weather chain: the very high energy electrons and ions magnetically trapped within Earth's radiation belts. The understanding gained by the Van Allen probes will enable us to better predict the response of the radiation belts to solar storms in the future, and thereby protect space assets in the near-Earth environment.

## Outline

- ▶ Capabilities for generating and broadcasting space weather data
  - ▶ Mission and Instrument Overview
  - ▶ Ground stations collecting the data
    - ▶ Data products
  - ▶ Collaboration with NOAA SWPC

## Van Allen Mission Facts

Second Living With a Star Mission  
Launch August 30, 2012  
Perigee: ~700 km altitude  
Apogee ~5.5 Re geocentric altitude  
Inclination ~10 degrees  
Sun pointing, spin stabilized  
Duration 2 years (+? expendables)

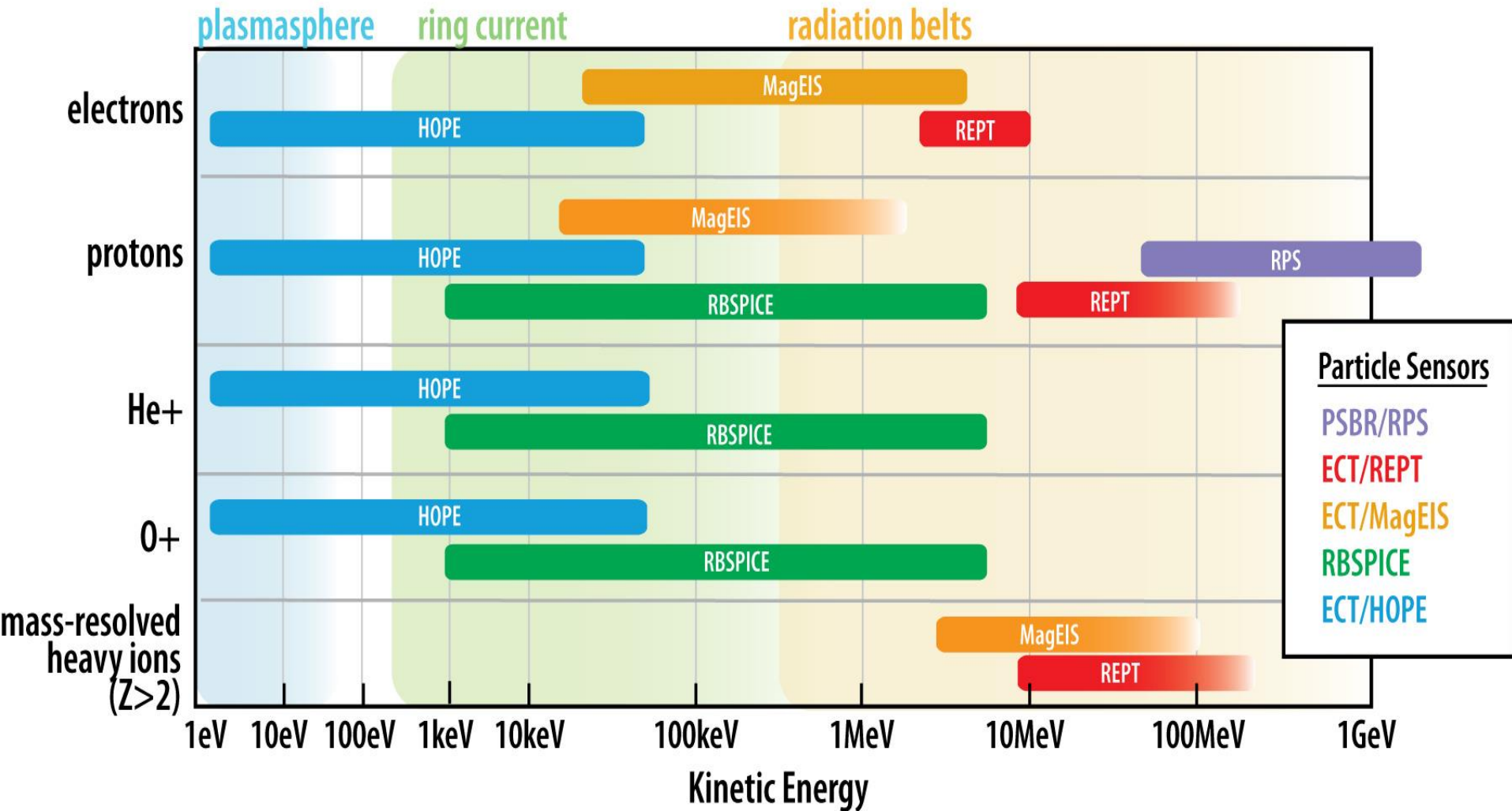
# Mission Overview



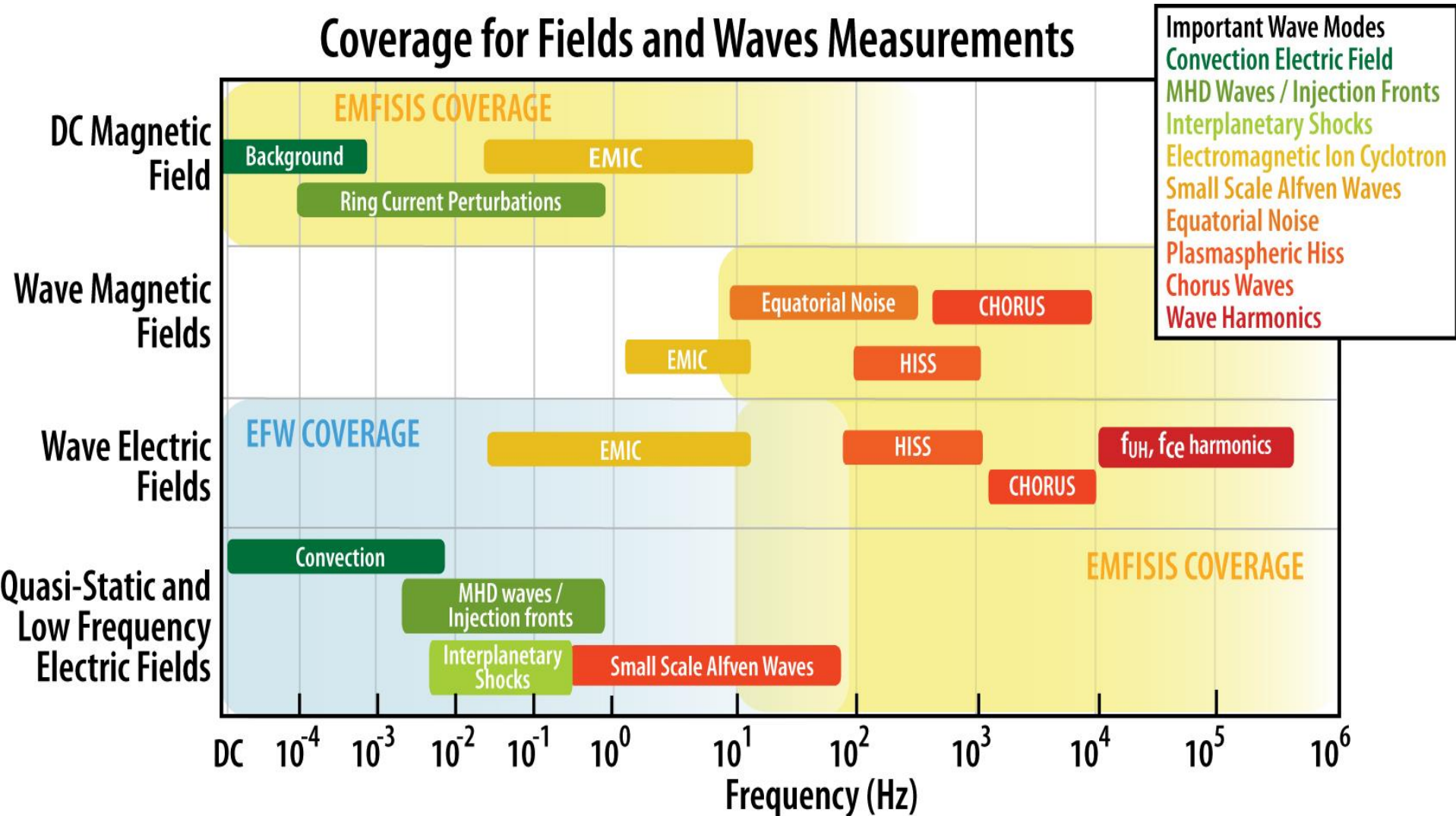
Provides understanding, *ideally to the point of predictability*, of how populations of relativistic electrons and penetrating ions in space form or change in response to variable inputs of energy from the Sun.

# Particle Experiments

## Coverage for Electron and Ion Pitch Angle Distributions

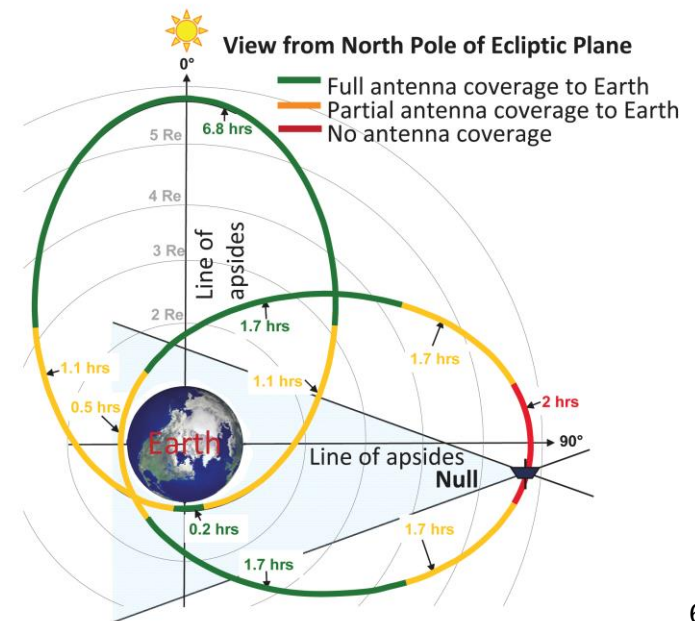
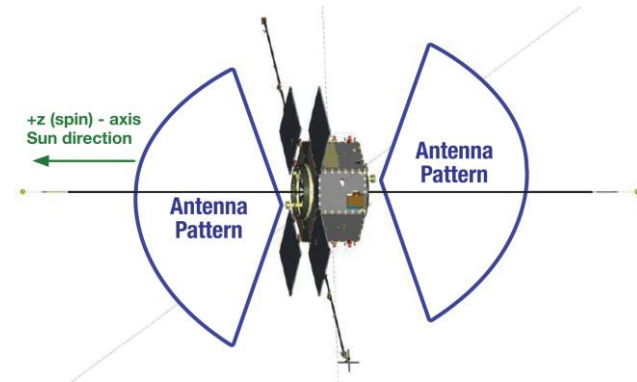


# Field & Wave Experiments



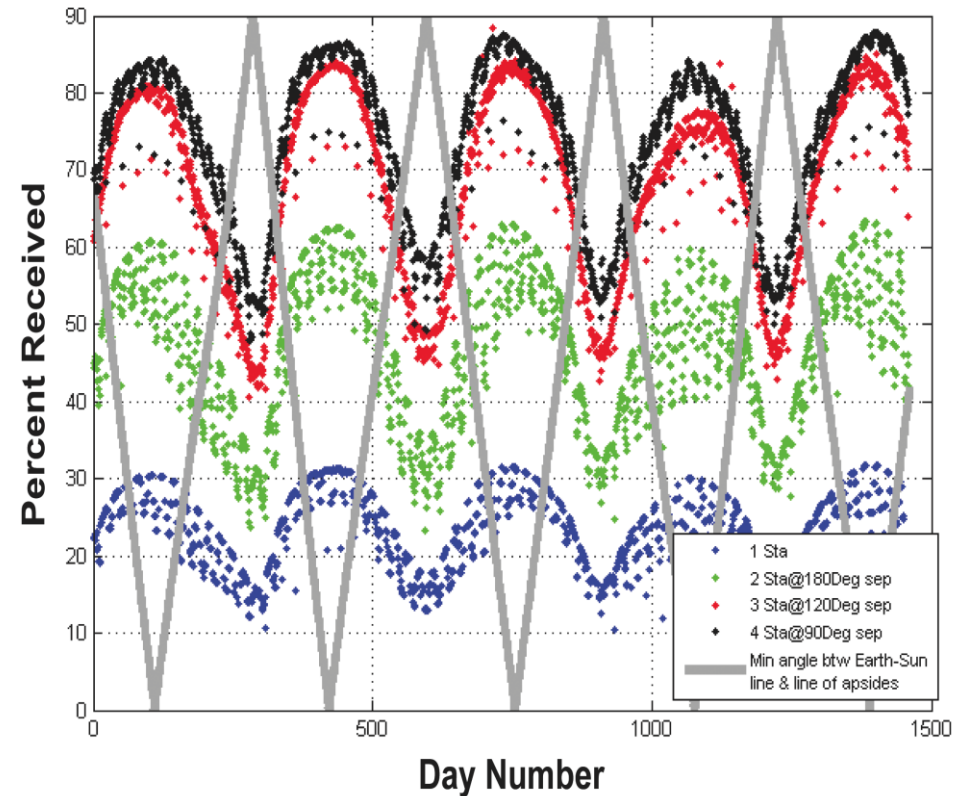
# Capabilities for generating and broadcasting space weather data

- ▶ Each satellite's sw broadcast  $\sim 21.5$  hr/dy.
- ▶ Each instrument has a sw product.
- ▶ The 2 RF antennas are aligned with the spacecraft spin- and anti-spin-axes, coverage of  $\sim 140^\circ$ .
- ▶ Both antennas are always active, only one has line-of-sight to Earth at any given time.
- ▶ Different regions of the orbit have communications downlinks that are robust, variable, or impossible.
- ▶ Stations near equator have best year-around coverage.



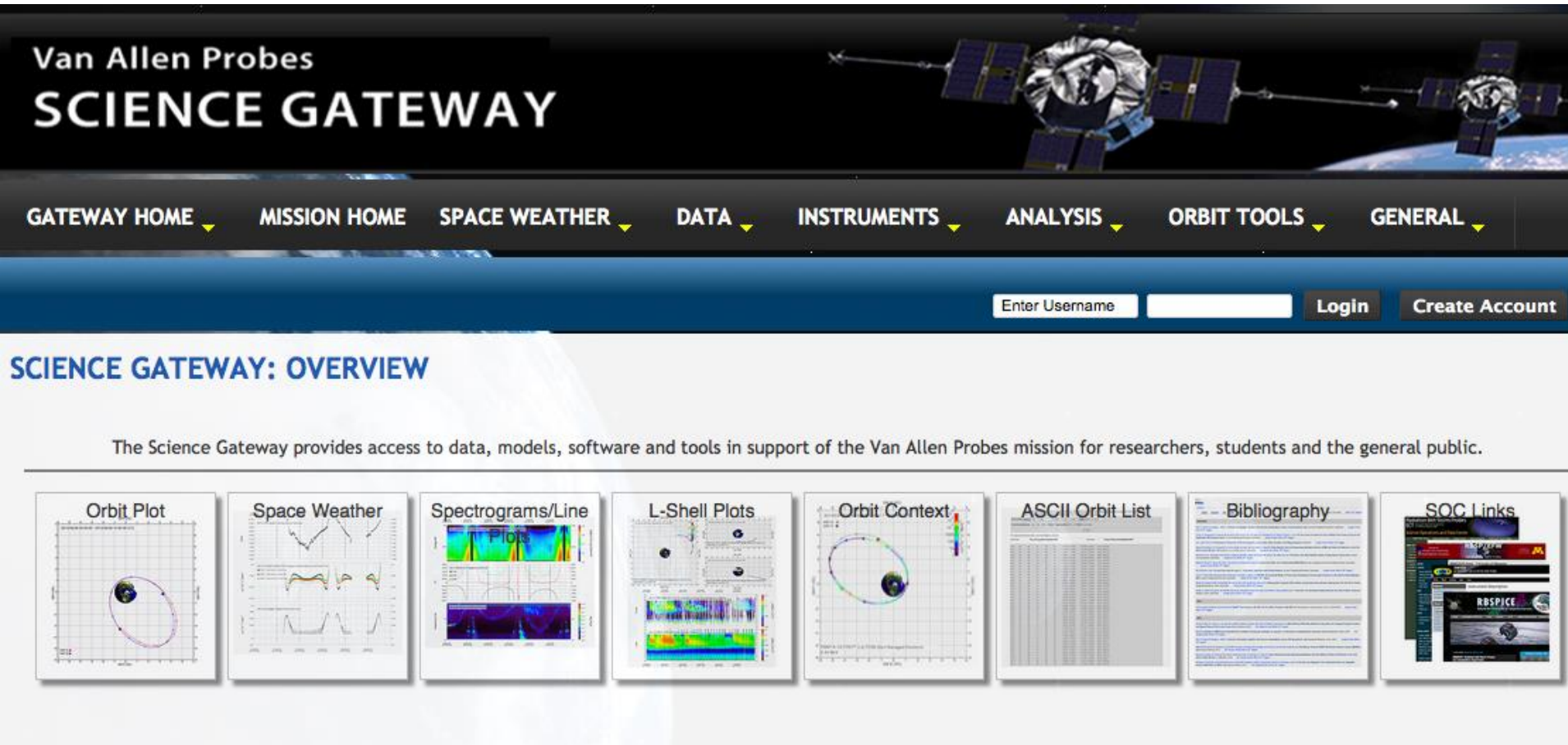
# Space Weather Data Coverage

- ▶ Multiple stations at diverse longitudes can maximize potential spacecraft contact duration as a function of the number of ground stations.
- ▶ Agreements in place with 4 ground stations
  - Korea Astronomy and Space Science Institute (KASI)
  - Institute of Atmospheric Physics, Czech Republic
  - National Commission for Space Activities (CONAE), Argentina
  - National Institute of Space Research (INPE), Brazil



# Van Allen Probes Gateway

The data are collected and processed at APL and then disseminated via Science Gateway tools



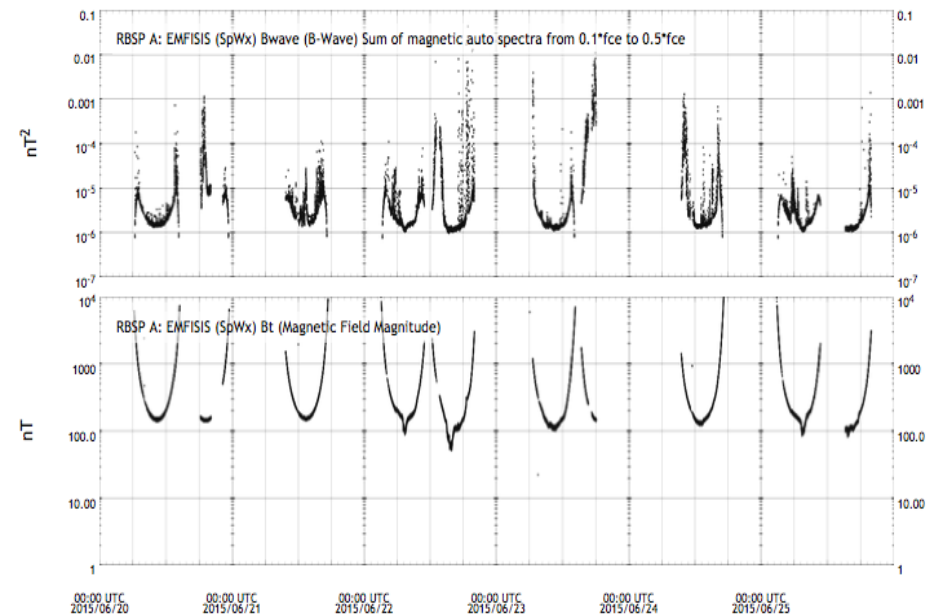
The screenshot displays the Van Allen Probes Science Gateway website. At the top, a banner features the text "Van Allen Probes SCIENCE GATEWAY" on the left and an image of the Van Allen Probes spacecraft in orbit on the right. Below the banner is a navigation bar with the following menu items: GATEWAY HOME, MISSION HOME, SPACE WEATHER, DATA, INSTRUMENTS, ANALYSIS, ORBIT TOOLS, and GENERAL. To the right of the navigation bar is a login section with a text input field labeled "Enter Username", a "Login" button, and a "Create Account" button. Below the navigation bar is a section titled "SCIENCE GATEWAY: OVERVIEW" with the text: "The Science Gateway provides access to data, models, software and tools in support of the Van Allen Probes mission for researchers, students and the general public." Below this text is a row of seven thumbnail images representing different tools and data visualizations: "Orbit Plot" (showing a satellite orbit around Earth), "Space Weather" (showing various space weather plots), "Spectrograms/Line Plots" (showing spectrograms and line plots), "L-Shell Plots" (showing L-shell plots), "Orbit Context" (showing a satellite orbit in context with Earth's magnetic field), "ASCII Orbit List" (showing a list of orbit data), and "SOC Links" (showing a list of links to related resources).

# Space Weather Data Description

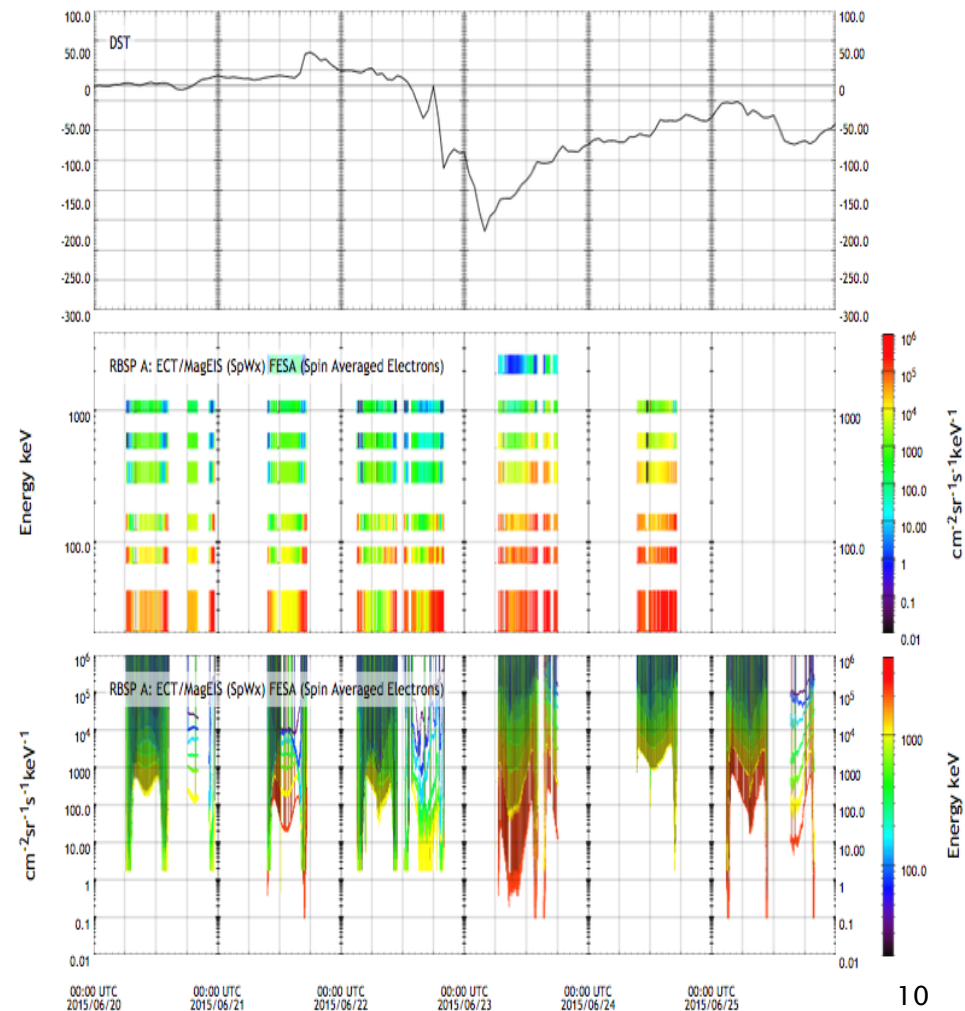
Instrument	Measurement	Energy
EMFISIS/MAG	Vector Magnetic Field	N/A
EMFISIS/Waves	VLF Wave Power	N/A
EFW	Vector Electric Field	N/A
	Spacecraft Potential	N/A
ECT/HOPE	Electrons	24.54 eV, 281 eV, 10.9 keV, 42.9 keV**
	Protons	24.54 eV, 281 eV, 10.9 keV, 42.9 keV
	Oxygen Ions	24.54 eV, 281 eV, 10.9 keV, 42.9 keV
	Helium Ions	24.54 eV, 281 eV, 10.9 keV, 42.9 keV
ECT/MagEIS	Energetic Electrons	30 keV, 60 keV, 100 keV, 300 keV, 600 keV, 1 MeV, 2 MeV
	Energetic Protons	1 MeV
ECT/REPT	Very Energetic Electrons	2 MeV, 5 MeV, 10 MeV
	Energetic Protons	>20 MeV, >50 MeV, >70 MeV
RBSPICE	Energetic Protons	50 keV, 100 keV, 150 keV, 300 keV, 1 MeV, 10 MeV
PSBR/RPS	Energetic Protons	>50 MeV, >400 MeV
	Dosimeter Data	Linear and Log outputs (Volts)

# Space Weather Example Data Plots

## Magnetic Field – wave power, magnitude

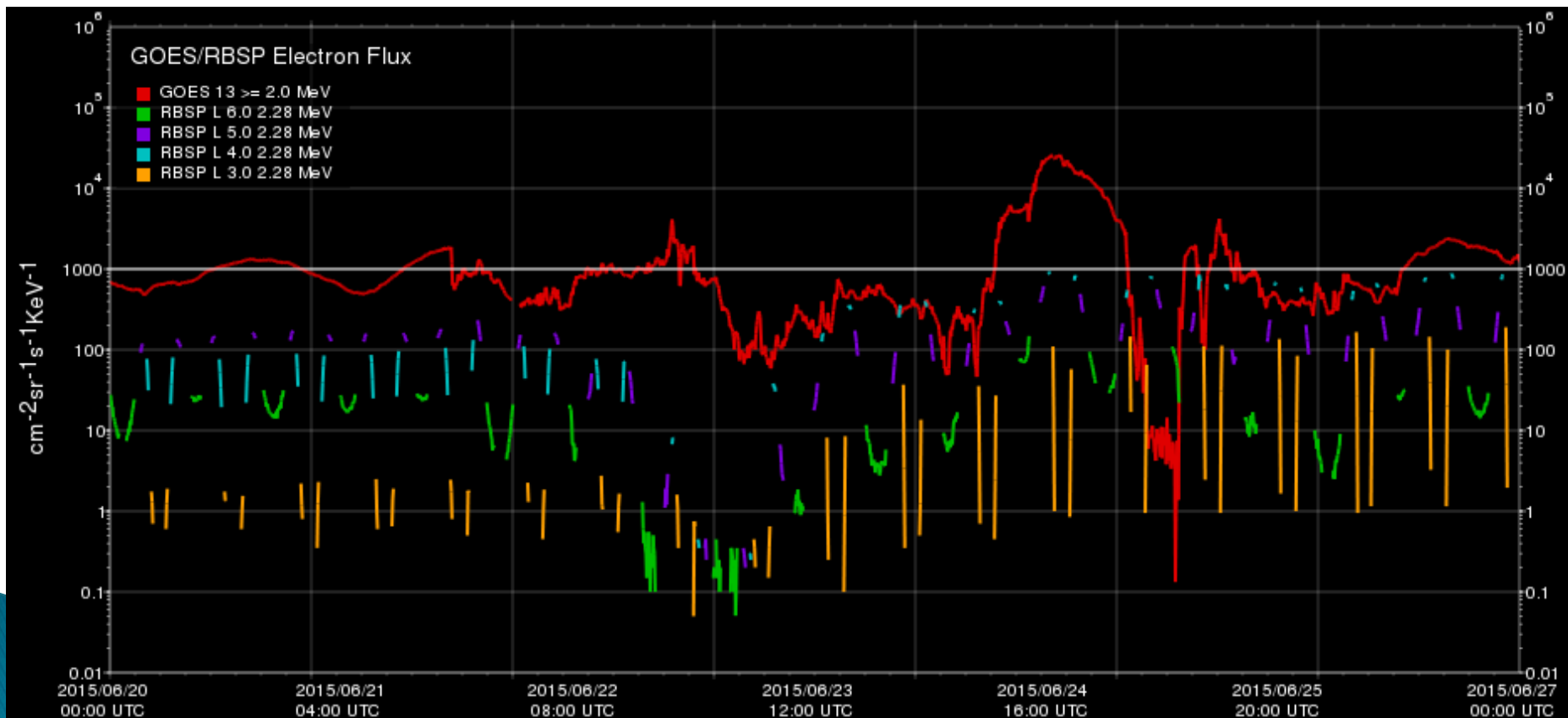


## Dst, MagEIS spin avg electrons (2 views)



# *Van Allen Probes near-real-time data products soon to be re-broadcast by NOAA SWPC*

- GOES characterizes radiation environment at GEO
- Van Allen Probes can fill in the L shells inside GEO

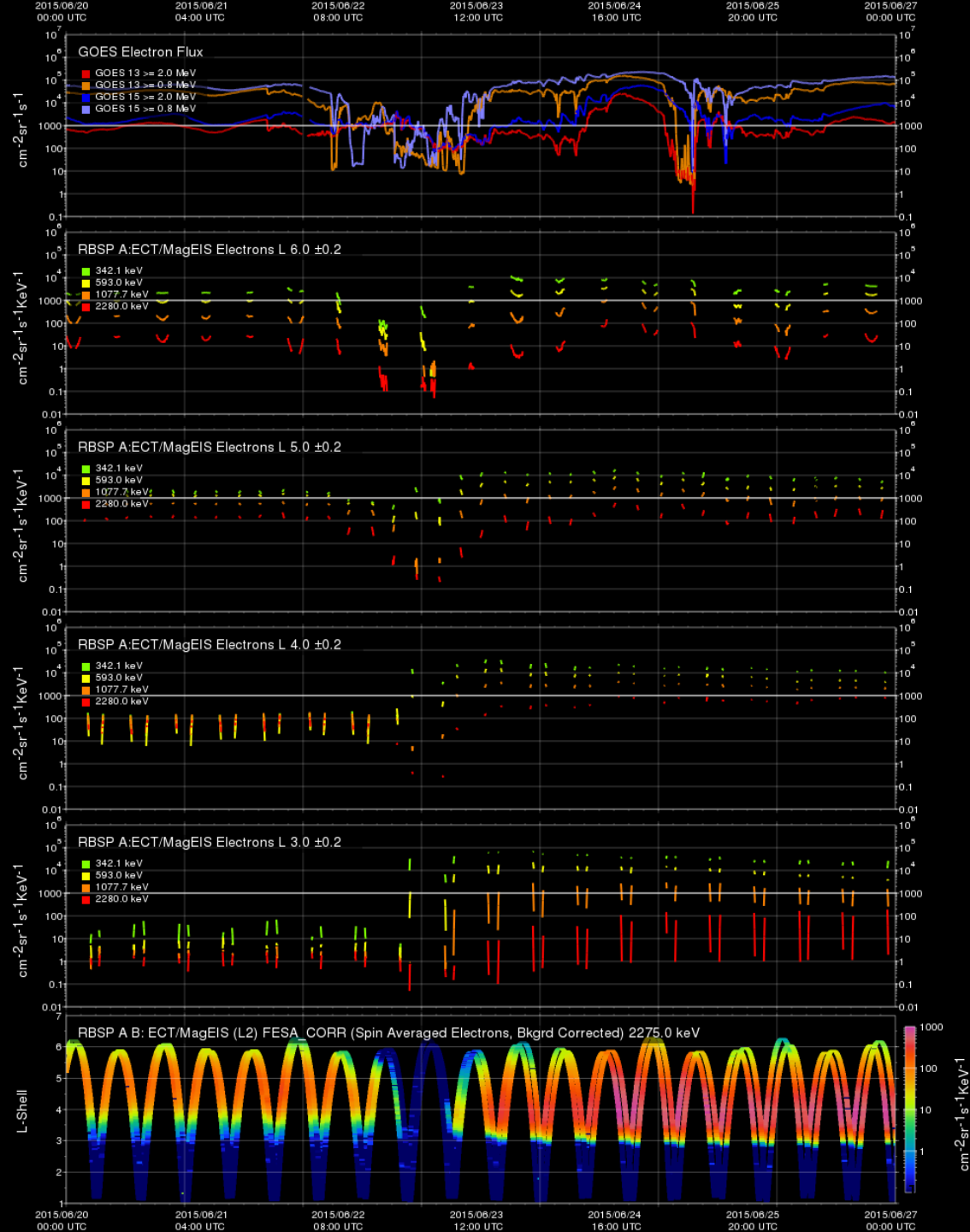


Lower energy electrons also show space weather effects

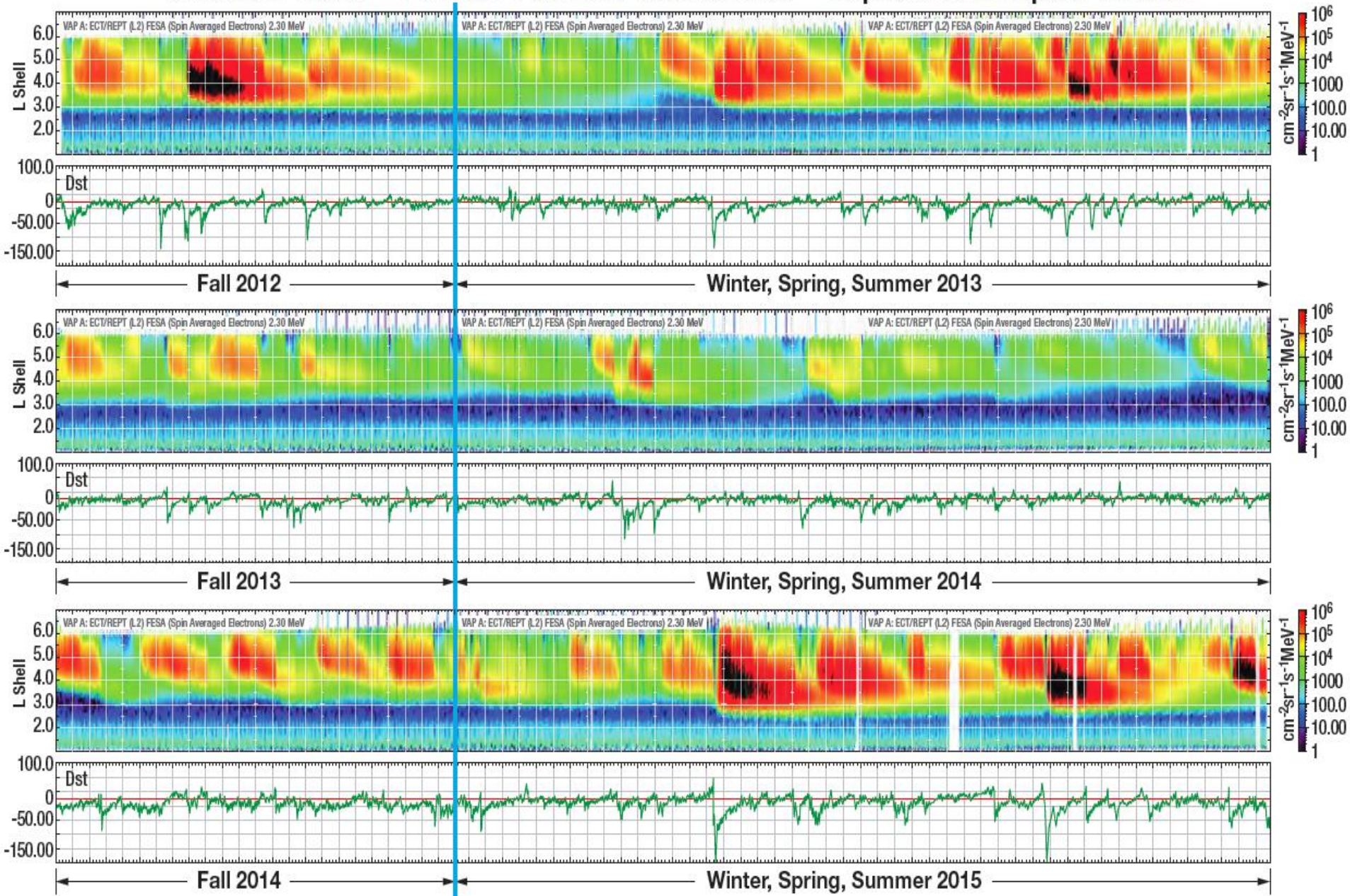
- 340 keV
- 590 keV
- 1.1 MeV

*L shells from 6 to 3.*

Van Allen Probes mission and NOAA SWPC are in process of finalizing the best inputs for forecasters.



# Van Allen Probes • ECT/REPT 2.3 MeV Electron Flux • Representative Space Weather



# Concluding Remarks

- ▶ The Van Allen probes continuously broadcast space weather data, except during prime science download and maneuvers. These data were selected to monitor the state of the radiation belts and will be used by NOAA SWPC to better space weather nowcasts.
- ▶ Currently four international partners have agreed to download this data and make it available for space weather data products. NASA is actively pursuing other ground station partners to fill in data gaps.
- ▶ The Van Allen probes have been designed to operate throughout the worst conditions expected in the hazardous radiation belt environment. The mission is significantly enhancing our understanding of radiation belt dynamics with changing solar wind conditions.
- ▶ The Van Allen probes will enable the prediction of extreme and dynamic space conditions, and will provide the understanding needed to design satellites to survive in space for future missions.